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NELAC I

NELAC II

Building EPA's Analytical Capabilities

Effluent Guidelines and Testing

Use of Proficiency Testing To Identify Systemic Problems
In Environmental Data

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ABSTRACT:

Proficiency Testing (PT) studies have been an integral part of environmental laboratory programs for over twenty five years. Air, water and soil PT studies have been conducted by the EPA, states and private organizations during this time frame. The primary purpose of the studies to date has been to support laboratory accreditation decisions or verify the attainment of program specific data quality objectives. In 1998, the EPA privatized their waste water, drinking water and radiochemistry PT programs. At the same time, the National Environmental Laboratory Accreditation Conference (NELAC) and several states began requiring laboratories to participate in privatized water and soil PT studies.

PT standards for these programs must be carefully designed to be homogenous and stable. As such the standards are generally manufactured in simple matrices, e.g., deionized water or clean soil, or as concentrates that require dilution by the laboratory immediately prior to preparation and analysis. Interferences are not routinely included in PT samples. PT manufacturers are also required to produce the standards that are "fit for use" which is generally interpreted to require that the standards to work with promulgated EPA methods. As a result of these design criteria, it can be argued that data for PT standards are at least as good as or better than that generated for actual samples.

The presentation will include an overview of the current NELAC and state PT programs and their impact on laboratory data quality. The main focus of the presentation will be an analysis of the PT data that clearly identify analytes and matrices for which current EPA methodologies, as presently practiced by laboratories, do not provide accurate results for PT standards and by implication actual samples. The presentation will also present data that identify the source of the less than quantitative recoveries. Examples will be presented where improvements in laboratory operations, the preparative method, or the determinative method would lead to improved results. Examples will also be presented that demonstrate that the use of promulgated EPA methods produce data of high quality.

The presentation will discuss how PT data can be used on an ongoing basis to focus resources on the development of methods that will substantially improve the quality of environmental data. Implications drawn from PT data on the successful implementation of the current method flexibility initiatives will also be presented.

Training Environmental Statisticians – Tomorrow's Problem Solvers

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ABSTRACT

*How could a win-win strategy be used to train young people in environmental statistics and at the same time analyze environmental data for Federal, State and local agencies, that have not been analyzed until now? This paper will discuss a course that has been developed to train undergraduate students in environmental statistics and the impact the course has had on the students, the clients and the university. This training comes in support of a National Science Foundation Grant, **Collaborative Research: Training Environmental Statisticians Using Complicated Data Sets to Make More Informed Environmental Decisions.** Currently, a collaborative effort is being undertaken with Spelman College, a historically black college for women in Atlanta, Georgia. This collaborative effort will demonstrate that this approach is portable to other universities and colleges with an undergraduate statistics program and at those without, as long as there are some courses in statistics and a statistician with an interest in environmental statistics. The intent of this collaborative effort is to adapt, modify and enhance the Environmental Statistics Practicum Program, which was developed at NC State University. The collaborators are currently implementing and adapting the environmental statistics program at Spelman College, which represents those colleges without a formal undergraduate statistics program. In summary, the classes have created a win-win situation for the students, the clients and the university and provide an alternative way to complete environmental data analysis. Examples of the students work will be presented in the paper.*

INTRODUCTION

For many years, the issues of how best to develop statistical partners in academe, industry and government have been raised (see Lynne Hare's bibliography: Statistical Partners in Academe, Industry and Government – Reference Literature on the web site: http://web.utk.edu/~wparr/hareexpect.html). These 77 references emphasize the importance of training statisticians to meet the needs of industry and government. All levels of government tend to collect large quantities of data, which largely go unanalyzed. This is particularly true with the collection of environmental data.

Cobb (1993[i]) has proposed that educators should (a) place less emphasis on mathematics and more emphasis on data analysis, (b) increase the use of data sets from domains recognizable to students and (c) to learn by doing. At North Carolina State University (NCSU), the benefits of coupling education and research have been described by anecdotes such as "...seemingly mediocre students caught fire after being involved in meaningful research." More authoritative support for research-based learning at the undergraduate level has been set forth in the Boyer Report (see Boyer, 1996[ii]). The BMS/NRC study

reported in Educating Mathematical Scientists: Doctoral Study and the Postdoctoral Experience in the United States (1992[iii]) cite the benefits of early involvement in research. In recent years, research universities have been criticized for ignoring their educational mission in favor of their research mission. The coupling of education and research, at least in the major field, turns a disadvantage into an advantage.

How can a win-win-win situation be created that would benefit students, faculty and government agencies and in the process encourage undergraduate students to pursue advanced degrees or careers in environmental statistics? A proof of concept study has been undertaken at North Carolina State University with the introduction of two new courses entitled Environmental Statistics Practicum and Special Topics in Environmental Statistics (see Hunt, 2000[iv] and Hunt, 2001[v]). The objectives of the environmental statistics courses are: (1) to provide a consulting opportunity for the students with Federal, State or local environmental agencies; (2) focus on the application of the student's technical skills to a real problem; (3) have the students gain consulting experience; and (4) develop their oral and written communication skills.

The students learn how to prepare a final report, brief clients at the client's office, present poster papers at technical conferences, and write papers for publication. Students have done work for eight clients: (1) the Southern Oxidant Study at North Carolina State University (NCSU); (2) the U. S. Environmental Protection Agency's (USEPA) National Exposure Research Laboratory; (3) the USEPA's Office of Air Quality Planning and Standards; (4) the USEPA's Office of Environmental Information in Washington, DC; (5) the North Carolina Department of Environment and Natural Resources (NCDENR); (6) the Forsyth County Environmental Affairs Department in Winston Salem, NC; (7) the U. S. Department of State; (8) Environment Canada; (9) the University of Texas; (10) the Texas Commission on Environmental Quality; (11) the USEPA Region 4 Office in Atlanta; and the (12) Georgia Department of Natural Resources. In addition to briefing their clients and providing the client's with final reports, they have presented papers at 22 professional meetings, research symposia, etc.

This work has addressed several critical areas:

1. The need to train undergraduates in analyzing important complicated and messy data sets.
2. The National, State and international need to analyze environmental data to make better environmental policy decisions.
3. The need to encourage students to pursue graduate degrees in statistics, keeping people in the pipeline to pursue PhDs.
4. The need to analyze real data for real clients in the workplace and make the student a desirable candidate for employment upon graduation.

BACKGROUND

There is strong evidence that information obtained through problem solving is better learned than information simply learned by rote (Adams, Kasserman, Yearwood, Perfetto, Bransford & Franks, 1988[vi]; Lockhart, Lamon & Gick, 1988[vii]). Conway, Cohen and Stanhope (1991[viii]) showed that memory for materials learned in a research methods course was enhanced by having students design and conduct experiments rather than passively learn about course content. The objective of this course is to have the students engage in active communication with their clients, understand the client's needs and then conduct an exploratory analysis of the client's data to answer the client's questions. The students visit an air monitoring site location to see how air monitoring data are collected and an air monitoring laboratory to see how the data are analyzed in the laboratory, as well. After the site and laboratory visits, the students focus on possible causes of uncertainty in the data collection process. The students learn how to apply their statistical and data analytic skills to the data and to present their results by developing their

speaking and writing skills. They interact several times over the course of the semester with their clients before they make their final presentations to their clients. The students have accomplished a great deal in this course. In addition to briefing their clients and providing the client's with final reports, they have participated in 22 professional meetings, research symposia, etc. The meetings they participated in are:

1. **The Southern Oxidant Study Data Analysis Workshop**, Research Triangle Park, NC, March 9, 2000.
2. **NCSU Undergraduate Research Symposium**, McKimmon Center, Raleigh, NC, April 27, 2000.
3. **USEPA Technical Workshop on PM $_{2.5}$ Monitoring, Quality Assurance, and Data Analysis**, Cary, NC, May 22-25, 2000.
4. **Air and Waste Management Association's Fourteenth International Symposium on the "Measurement of Toxic and Related Air Pollutants,"** Research Triangle Park, NC, September 12-14, 2000.
5. **Future Directions in Air Quality Research, Ecological, Atmospheric, Regulatory/Policy and Educational Issues**, Research Triangle Park, NC February 12, 2001.
6. **NCSU Undergraduate Research Symposium**, McKimmon Center, Raleigh, NC, April 19, 2001.
7. **NC Department of Environment and Natural Resources Data Analysis Colloquium**, Raleigh, NC, May 23, 2001.
8. **Second Annual NC State University Minority Graduate Education (MGE) Summer Research Program Poster Session**, July 23, 2001.
9. **Mathfest 2001**, sponsored by the Mathematical Association of America and Pi Mu Epsilon, Madison, Wisconsin, August 2-3, 2001.
10. **Sigma Xi Student Research Symposium**, Raleigh, NC, November 10, 2001.
11. **NCSU Undergraduate Research Symposium**, McKimmon Center, Raleigh, NC, April 18, 2002.
12. **North Carolina Department of Environment and Natural Resources Data Analysis Colloquium**, Raleigh, NC, May 23, 2002.
13. **First Annual NC State Undergraduate Summer Research Symposium**, Raleigh, NC. August 9, 2002.
14. **Joint Statistical Meetings**, New York City, New York, August 11 - 15, 2002.
15. **Air & Waste Management Association's Annual South Atlantic States Section Meeting**, Research Triangle Park, NC, December 4, 2002.
16. **NCSU Undergraduate Research Symposium**, McKimmon Center, Raleigh, NC, April 10, 2003.
17. **96th Annual Air & Waste Management Association Meeting**, San Diego from June 22-26, 2003.
18. **Second Annual NC State Undergraduate Summer Research Symposium**, Raleigh, NC. August 9, 2003.
19. **Triangle University Undergraduate Research Symposium**, Duke University, Durham, NC, Nov. 1, 2003.
20. **2004 Water Resources Research Institute Conference**, McKimmon Center, Raleigh, NC, March 30-31, 2004.
21. **NCSU Undergraduate Research Symposium**, McKimmon Center, Raleigh, NC, April 22, 2004.
22. **97th Annual Air & Waste Management Association Meeting**, Indianapolis, IN from June 22-25, 2004.

After five years, five students have graduated with a master's degree in statistics and two are continuing on for a Ph.D. Twelve students have gone onto graduate school programs in statistics. Six students are employed at the Research Triangle Institute as environmental statisticians and ten students have worked part time at the USEPA as statisticians. The students have given 71 professional presentations and have written almost as many papers and reports.

COURSE DESIGN

Lecture Segments

Lectures occupy the majority of class time in college courses (Mathie, et al., 1993[ix]). The approach used in this course is to provide lecture material for the students to increase their understanding of the environmental issues that they will encounter when working on the problems for their clients. Team training is also an important component of the course material. Peters and Waterman (1982[x]) state that one of the key principles practiced by "excellent" companies was strong employee participation. Bradford and Raines (1993[xi]) show that today's young workers are learning new management models in college that give more power to front-line employees and flatten the organizational chart. Team training is an important aspect of the new workplace. Kelly (1996[xii]) defines a team as a small number of people with complimentary skills who are committed to a common purpose, set of performance goals, and an approach for which they hold themselves mutually accountable. The lessons with team training make use of material provided by Whitney (1996[xiii]), whose work was done for the USEPA's Office of Air Quality Planning and Standards. Statistical methods and the types of presentations used in environmental data analysis are an important part of the lecture material. The availability of written material in both handout form and it's availability on the web page allows students to concentrate on spoken lectures without being troubled by the need to take notes. The lectures occupy approximately half of the class time. Field trips to air monitoring sites and laboratories are incorporated into the course so that the student can see how the data are collected and to better understand the possible sources of error associated in data collection. The students meet their clients at the client's place of business. This is done to reinforce the importance of the analysis that they are undertaking for the client. The students' briefings and reports examine data that have not been analyzed before. The students present their findings in a number of ways – formal briefings (30 minutes) with questions and answers, abridged briefings (10 to 15 minutes) with questions and answers, and poster presentation briefings (2 minutes) with questions and answers. The students are trained using traditional approaches - overheads and handouts. There has been some use of the multimedia projectors with presentations written in PowerPoint. They also learn to give briefings using handouts in a conversational mode. For long distance clients, such as Environment Canada, the students learn how to give briefings using teleconferencing or via conference call.

Several initial homework assignments are used for the students' first problem. The initial homework assignment could include an examination of lead air monitoring data. Here the students examine the policy implications associated with interpreting the results of an analysis of variance of lead monitoring data (Hunt, 1984[xiv]). Alternatively, a simple data collection effort could be undertaken to test a hypothesis. Both types of problems foster teamwork, dividing parts of the problem among team members and providing a baseline measure of the students' ability to conduct a briefing. The second type of problem is illustrated with the fall 2001 class, which was asked to examine the question (a positive environmental effect): "Are the students, faculty and alumni of NCSU more likely to drive a red car, because they are associated with NCSU, than is the general public?" This sample exercise went very well with the students dividing themselves into three teams. Each team addressed the question for the students, faculty and staff or the alumni. A student reporter for the student newspaper, The Technician, was invited to the student presentations. Their work was so well received that it was reported in the student newspaper, The Technician[xv] and carried on the university wire service. Additional examples will be developed as part of the course materials.

Statistical Methods

The students employ classical statistical methods to their analysis of the data. Smith (1998[xvi]) found very positive effects of incorporating active-learning strategies in his classes. The activities allowed students to learn about statistics by getting first-hand experience in conducting statistical analysis. By designing studies, collecting and analyzing data, and preparing written reports, students come to see the importance of statistics and gain interest in and excitement about examining whether the results support their predictions and what they reveal about the data that the students have analyzed. The Environmental Statistics Practicum takes this one step further by having the students work with real clients, analyze the client's data, interpret it, brief the client on the results of their work and write a written report. Often their work is of such a high quality that the students prepare poster presentations for the NCSU Undergraduate Research Symposium and make presentations before professional society and technical meetings. The students employ many different statistical methods depending upon the nature of the question being raised. The problems could involve forecasting (Harrington, 2000[xvii], and Woodside, 2001[xviii]). Both of these papers by students - Daric Harrington and Kathy Woodside - received cash awards for best papers at the NCSU Undergraduate Research Symposium and the Mathfest 2001 Meeting, respectively. The Mathematical Association of America and Pi Mu Epsilon in Madison, Wisconsin sponsored the Mathfest 2001 Meeting. Kathy Woodside's summary of her PM fine predictions is shown in Table 1. Clearly, the summer model is better than the winter model. Karen Donaghy and Courtney Sorrell extended this research by responding to a question raised by Environment Canada. Instead of using a 24-hour measurement of PM fine, they used a daily 3-hour maximum average. Environment Canada wanted to know if it would be easier to predict a 3-hour maximum average. They greatly improved the ability to forecast PM fine by developing models to forecast both weekend and weekday by season (They improved the accuracy to 81 percent, lowered the false alarm rate to 19 percent, increased the critical success index to 57 percent and increased the probability of detection to 70 percent. Each of these statistics is an improvement over the winter prediction in Table 1. Each student received a $2000 Undergraduate Research Award from North Carolina State University to continue their work in the spring semester of 2003.

The students examine data using scatter plots, correlation analysis, regression analysis, analysis of variance, etc. (McMichael and DeFrancis, 2000[xix]; Madsen, Copeland and Crotty, 2000[xx]; Cason, Clarke and Ness, 2001[xxi] and Bartz and Woodside, 2001[xxii]). Other statistical methods examining spatial patterns and trends are also being used (Copeland, 2001[xxiii], Crotty, 2001[xxiv] and Thomas, Brooker and Cheng, 2001[xxv]). Brian Copeland in a project for the USEPA demonstrated that standard conditions of temperature and pressure resulted in a positive bias in air toxics measurements in the Western States when compared with using local conditions of temperature and pressure. Based upon his work the USEPA will change its requirements so that air toxic data will now be reported in local conditions of temperature and pressure. (See Figure 3).

Another analysis conducted by Schnell, Gabig and Spruel (2002[xxvi]) provided a basis for changing the form of the fine particulate matter standard in the future. A question rose in the recent workshop held by Environment Canada, "Towards a Canadian Air Quality Index"[xxvii] will be explored: "Could a three hour standard be used instead of a 24-hour standard?" In order to do this there must be a correlation between different particulate matter indicators. The students answered this question in the affirmative in the analysis they did for Environment Canada. (See Figure 2).

Table 1. Comparison of winter and Summer PM fine Forecasting Models in Forsyth County, North Carolina.

	Winter	Summer
Accuracy	72.4%	92.0%
False Alarm Rate	39.2%	7.6%
Critical Success Index	38.3%	89.0%
Probability of Detection	50.8%	96.1%

Figure 2.   Standard Conditions of Temperature and Pressure vs. Local Conditions
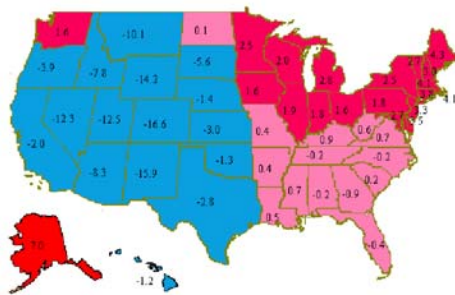
Figure 3. Comparison of PM$_{2.5}$ daily maximum 3 hour average with the the 24-hour average in Kitchener, Ontario, Canada.
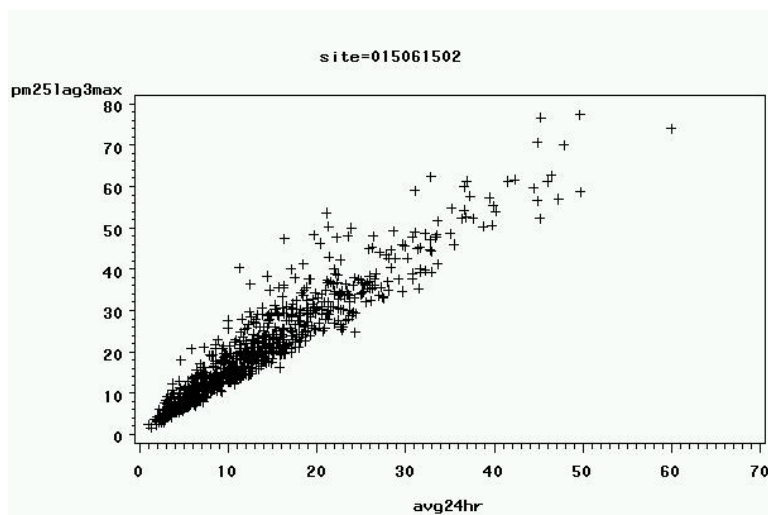
R = .94709   **Kitchener, Ontario**

Our three students – Jeffrey Thomas, Darious Brooker and Ho Ling Cheng—went on to win an undergraduate research award for their work. Each student received a $2000 scholarship in the Spring 2002 semester from NCSU to continue with his or her statistical analysis of the Toxic Release Inventory data. Quality control techniques are also used to examine problems (Gallins, Stidham and Bartz, 2001[xxviii]). The report prepared by students – Paul Gallins, Sam Stidham and Janet Bartz will be used to change the quality control procedures used in the chemical analysis of volatile organic compound data under by the NCDENR. In 2002-2003, Karen Donaghy and Courtney Sorrell each won the $2000 scholarship and in 2003-04, seven students – Brian Currier, Louise Camalier, Ornella Darlington, each won the $500 Undergraduate Research Award for their projects.

Prototype

A prototype of the materials that have been developed can be viewed at:
http://www.stat.ncsu.edu/~st495a_info/.

SPELMAN COLLEGE COLLABORATION

Spelman College will hold a summer research institute called the Spelman Summer Environmental Statistics Institute (SSESI) starting in June, which will give students the opportunity to spend six weeks during the summer to participate in an environmental statistics practicum. Six students are slated to participate in the summer program. The Spelman approach seeks to expose students to a highly interdisciplinary research environment where they will not only be involved in statistical analysis of environmental data, but will also explore issues such as environmental justice, impacts of environmental air quality on communities, and the often differing perspectives of academia, industry, and the community on environmental air quality. The students that participate in the program are required to either have credit for an undergraduate-level course in statistics or they will participate in the Special Topics course on environmental statistics the summer prior to their participation in SSESI. Lectures in environmental statistics have been developed for the students to take during the Summer Institute. Theses lectures should be transferable to other colleges without a formal statistics program, who might decide to teach this type of environmental statistics program in the future. In addition, lectures in the use of Geographical Information Systems as applied to environmental data analysis will be developed and given to the students during the Summer Institute. Students at Spelman College will apply this software. SSESI will be held during the summers of 2004, 2005, and 2006.

The objectives of SSESI are to:
- Involve students in interdisciplinary research on the undergraduate level and have them feel that they are making a valuable contribution.
- Introduce students to statistics and to the application of statistical methods to "real world" problems.
- Introduce students to geographical information system methods as well as the analysis of "real world" environmental problems.
- Encourage students to pursue advanced degrees in either mathematics/statistics or in some other area of environmental research.

During the institute, the students will meet and consult with a client(s) and evaluate the needs of the client. They will use the methods they learned from the Special Topics Course. They will present their results to the client and at appropriate symposia and technical and professional meetings. The students will be paid a stipend of $2000.00 for their participation in the institute and will be provided with room and board from SSESI at Spelman College.

As a result of their experience the students will be exposed to research and statistics and will, it is hoped, plan to do graduate work in environmental statistics or other related fields. They may decide to pursue careers in environmental statistics. Ultimately, the students will gain practical experience and skills in research.

RECOMMENDATIONS AND CONCLUSIONS

This course demonstrates that a win-win-win situation can be created that benefits students, faculty and government agencies and in the process encourages undergraduate students to pursue advanced degrees and/or careers in environmental statistics. This prototype works. We believe that this course can be duplicated at other universities in partnership with government agencies. The work at Spelman College strongly suggests that a similar environmental statistics practicum can be developed at colleges without a formal undergraduate program in statistics. Similar courses could be constructed with other government agencies or private corporations. We are looking for interested partners that we can work with to implement this course. Government agencies tend to collect vast quantities of data that are rarely turned into information. This course is designed to turn data into information for the benefit of students, faculty and their clients and the general public!

All aspects of the course, lectures, data bases and student reports and papers will be freely available on the Internet.

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Continuous Improvement and Validation of EPA Method 1668A - Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids and Tissue by HRGC/HRMS

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Abstract:

In March of 1997, EPA released Method 1668 for determination of the 13 dioxin-like congeners listed by the World Health Organization (WHO) in 1994. Between 1997 and 1999, EPA expanded Method 1668 for determination of all 209 congeners and validated the expanded method in an extensive single laboratory study. EPA performed a peer review of the expanded method and revised the method based on comments received in the peer review. The revised, peer-reviewed method was renumbered as Method 1668A. In 1999, EPA published a report of the single-laboratory validation study and the peer review.

Since 1999, EPA has been collecting comments on Method 1668A, including corrections and suggestions for improvement. The improvements are part of a methods initiative by several EPA Regions and EPA's Office of Science and Technology (OST). The comments, corrections, and suggestions received were incorporated into a revision to Method 1668A in August of 2003 in preparation for an interlaboratory method validation study. A plan was written for the study in early 2003, and was reviewed by OST and the EPA regions involved in the regional methods initiative. The study, which includes participation by 14 laboratories, commenced in November of 2003.

The interlaboratory method validation study involves standardization of the HRGC/HRMS instrument will all 209 congeners, and analysis of reagent water, wastewater, biosolids (sewage sludge) and fish tissue samples. The data gathering portion of the study is expected to be complete at the time of this presentation, and the presentation will give preliminary study results. It is anticipated that the method will be revised based on the results of the study and comments received.

A New Tool to Support the Quality of
CWA's Whole Effluent Toxicity Testing Programs under the Clean Water Act (CWA)

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Abstract:

Whole effluent toxicity (WET) tests are laboratory experiments deigned to measure the biological effect of effluents on freshwater and marine organisms. Acute and chronic WET tests play an important role in allowing EPA and states to fulfill their obligations under the CWA National Pollutant Discharge Elimination System (NPDES). In a typical WET test, groups of organisms of a particular species are held in test chambers and exposed to different concentrations of an aqueous sample (e.g., a reference toxicant, an effluent, or receiving water, and observations are made at pre-determined exposure periods. At the end of the test, the responses of the test organisms are used to estimate the effects of the toxicant or effluent.

Although the development of WET tests dates back to the 1950s, first with a focus on acute toxicity tests and later with the development of short-term chronic testing, a number of challenges concerning implementation of these tests in NPDES permits persist today. This paper describes the proposed creation of a WET Technical Support Center (TSC) that would serve as a centralized source of technical expertise and institutional knowledge to address these challenges in an organized, consistent manner. The TSC also would serve as a distribution center for information, training, guidance, and other materials intended to improve the quality of WET testing nationwide and promote consistency in the use of WET tests for permitting.

Application of the Effluent Guidelines Data System for Review of Primary Data

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Abstract:

The U.S. Environmental Protection Agency's Office of Water is responsible for developing effluent limitations guidelines and standards under Section 304(m) of the Clean Water Act. Development of these guidelines and standards requires a detailed evaluation of wastewater discharges and treated effluent, including sample collection, sample analysis, and an evaluation of the resulting data. These data are used to determine the characteristics of the wastewater and sludge, pollutants of concern, effectiveness of the technology at reducing and removing the pollutants, the concentration of pollutants in the discharges (usually effluents), and variation in day-to-day treatment performance.

The goals of the data gathering and review process are to ensure analytical data are of high quality and meet study quality objectives. Data gathering and review must produce results in a consistent and cost-effective manner, maximize data usability, and meet deadlines to ensure regulatory schedules are not compromised. To meet these requirements, data are generated using approved analytical methods that incorporate quality control requirements, including limitations for detection and quantitation. Data reporting and review follow a standardized process that can be customized to meet study needs. The multi-step data review process is designed to provide a comprehensive and timely assessment of data quality, and includes summary-level review, completeness check, instrument and laboratory performance checks, method performance evaluation, and assessment of data quality and usability. Cradle-to-grave planning, implementation, and management of these data collection and review processes are necessary to ensure data used to develop effluent guidelines and standards are valid, scientifically sound, and legally defensible.